on one side and three on the other, while the disk looks as if it had been cut in two by a knife, and three new arms had then grown out from the cut side.

Echinoderms as a rule, then, are reproduced alone by eggs and sperm cells. After fertilization of the egg they pass through:

1. Morula stage.
2. Gastrula stage.
3. A larval, temporary stage (Pluteus, Brachiolaria, Auricularia).
4. The Echinoderm grows from a water tube of the larva, finally absorbing the latter, whose form is often materially changed during the process. It thus undergoes a true metamorphosis, in a degree comparable with that of some insects.

LITERATURE.

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## REVIEWS AND BOOK NOTICES.

THE GEOLOGICAL SURVEY OF MISSOURI. — We have too long delayed our notice of the two octavo volumes from the geological survey of Missouri, which, though bearing the date of 1873, were not distributed till 1874. The first of these is a collection of reports from 1855 to 1871, by Messrs. Brodhead, Meek & Shumard, and the second, the results of the work of 1872, is devoted to the iron and coal deposits of the state. Of these the former are described by Dr. Adolph Schmidt, and the latter by Mr. Brodhead; in addition to which the late director, Prof. Raphael Pumpelly, has prefixed an important chapter on the geology of the Pilot Knob district, and its iron ores, from which, and from the copious descriptions of Dr. Schmidt, we gather a pretty complete account of this extremely curious region. Rising above the floor of horizontal palæozoic deposits, the 3d Magnesian limestone of Swallow, a member of a group of strata supposed to correspond to the Potsdam of New York, appear numerous hills of crystalline rock, described as exposed portions of the skeleton of the eastern part of

the Ozark Mountains; which formed an archipelago in the palæozoic sea, and are now from 300 to 700 feet above the limestone at their base. The Pilot Knob group includes four of these, and the Iron Mountain is another and distinct mass. All of these consist wholly or in part of quartziferous porphyry or orthophyre, but in the vicinity of these porphyry hills are others composed of granites, often chloritic or hornblendic, some of them capped by the porphyry which is considered as a newer rock, and, it is suggested by Pumpelly may be the youngest member of the Eozoic (Archæan) rocks of the region. He, however, adds in a note that the red granites may be an exception to this supposed rule. These porphyries present some considerable variations in character, but may be described as having a fine grained compact base or matrix with conchoidal fracture, composed of an intimate mixture of feldspar and quartz, in which are generally disseminated small crystalline grains of vitreous quartz, and crystals of pink or white feldspar, generally triclinic. The colors of this rock are various shades of yellow, red, gray, brown and black, and it is often banded in its structure, sometimes exhibiting thin layers, occasionally with alternations of quartz, in addition to which, according to Pumpelly, it is stratified on an immense scale. Epidote, chlorite and a steatitic mineral occasionally occur in it, and magnetic and specular iron ores are often disseminated through the mass. To those familiar with the geology of our eastern coast it is only necessary to say that these porphyries seem to be identical with those of Lynn, Saugus, Marblehead and Newburyport, Massachusetts, which are traced thence along the coast of Maine and New Brunswick, and are well developed about Passamaquoddy Bay, where they occasionally contain small deposits of iron ore. These porphyries have already been compared by Hunt with those of Missouri and with similar ones on the north shore of Lake Superior. As seen on the coast of New Brunswick, they are, according to him, intimately associated and interstratified with schistose rocks, supposed to be of Huronian age.[1]

At Pilot Knob, the excavations in the ore-deposit have exposed a considerable section of the strata, which dip at a moderate angle to the southwest, and consist at the base of several varieties of banded porphyry, one of these containing iron ore in grains and

[1] T. Sterry Hunt, Chemical and Geological Essays, p. 187.

in streaks. Above these lies a thin layer of clay slate, followed by a great mass of bedded iron ore (about forty feet) divided into two parts by a layer of a few feet of clay slate, talcose in parts. The upper portion, which is thin-bedded and flag-like, is less pure than the lower, containing a considerable admixture of silicious matter, and is overlaid by about 100 feet of well-bedded conglomerate rock, consisting of pebbles or more or less angular fragments of porphyry and gray quartz, in a matrix of granular iron ore, occasionally with grains of quartz and a soft clayey matter. In the lower part of this the conglomerate character is less obvious, and it appears to be a uniform ore-bearing porphyry with thin layers of fine conglomerate. The iron oxyd is essentially hematite or peroxyd, but the rock possesses a decided magnetic polarity. While the great deposit of ore is here newer than the porphyry, and seems to be the cement of a conglomerate made up of the ruins of this rock, it is found in the Iron Mountain in this region, in veins intersecting a clayey material, which is nothing but the porphyry decomposed *in situ*. In a deeper cutting, however, the hard unaltered porphyry has been met with. Prof. Pumpelly calls attention to several curious phenomena dependent upon the decay of the crystalline rocks in this region. In some cases partial decomposition of the granites has left at their outcrop great polygonal rounded blocks, often hundreds of tons in weight. Elsewhere, the chloritic granites for fifty feet, and probably for many times that depth, are completely disintegrated and decomposed. In the case of the decayed porphyry of the Iron Mountain, the effect of the atmospheric waters upon this mass, "part iron and part clay," has been to remove the latter, so that when the mountain was first examined, it exhibited a layer of from four to twenty feet or more in thickness, of rounded masses and grains of pure compact red hematite or specular ore, with very little clay. This residual detritus, as remarked by Pumpelly, represents a great amount of porphyry decomposed and removed since the ore-veins bear but a small proportion to the whole mass of the rock. In the sediments around the base of the mountain are large stratified accumulations of similar detrital ore, which were washed down the slope and "concentrated by the waves of the Silurian ocean," thus showing the great antiquity of this process of decay.

The ore at Cedar Hill near Pilot Knob is compact, holding grains of limpid quartz, and has, according to Pumpelly, the as-

pect of a porphyry, in which the whole matrix has been replaced by iron ore. This forms irregular masses in ordinary porphyry, which in other localities contains iron ores highly manganesian, and even deposits of nearly pure oxyd of manganese. Crystals of orthoclase, feldspar and grains of quartz, are found imbedded in a compact manganese ore, which, according to Pumpelly, may be supposed to have replaced the matrix, leaving the crystalline elements intact, while in other portions the replacement has been complete, manganese-oxyd taking the place of the grains of quartz, and the feldspar crystals. With these manganiferous porphyries is associated carbonate of lime, sometimes forming layers of pink and greenish crystalline limestone several inches in thickness, interlaminated with a schistose jaspery or porphyroid rock. To account for these various associations, Prof. Pumpelly suggests two hypotheses, the one that the porphyry, both matrix and included crystals, may have been replaced by oxyd of iron or of manganese, and the other that the parent rock may have been a limestone, parts of which were changed into ore by a similar replacement, "while the porphyry now surrounding the ores may be due to a previous, contemporaneous or subsequent replacement of the lime-carbonate by silica and silicates." The important fact is noted that chemical analysis shows that the remaining porphyry, intimately associated with the ore, has undergone no change, but retains its normal constitution.

The ore-deposit of Iron Mountain is, according to Dr. Schmidt, a great irregular vein of specular ore, more or less split up, and including masses of wall-rock, but accompanied by numerous smaller veins. He supposes the ore to have been deposited in fissures in the unaltered porphyry, which was further cracked and fissured by the crystallization of the ore, while this was itself subsequently broken by the contraction and the decomposition of the porphyry; in fact, the angular fragments of ore in the latter can scarcely be otherwise explained. The writer can, from his own observations, bear witness to the careful statements of facts in the case of these curious ore-deposits as given in the present volume, and affirm that the singular perplexity of the phenomena at the Iron Mountain can scarcely be better described or explained than has been done by Dr. Schmidt. As regards the origin of the ore-deposits Dr. Schmidt considers the various hypotheses of igneous injection, of sublimation and of segregation, and rejects

them in turn, in favor of that of aqueous deposition from infiltrating waters. The ores at Shepherd Mountain are similar vein-deposits, but the porphyry is here seen in an undecayed state.

As regards the very unlike deposits of Pilot Knob, Dr. Schmidt accepts the first hypothesis of Prof. Pumpelly, and supposes that solutions, similar to those which deposited the ore in the fissures of the porphyries elsewhere, have here effected the conversion of the porphyry into ore. It is, as he admits, difficult to explain in this view, the removal of the resulting silicate of alumina, and not less difficult to explain the removal or replacement of the quartz, as supposed by Pumpelly. When we consider that iron oxyds are frequent elements in gneissic and other crystalline rocks, and that they have been directly deposited in later sedimentary formations, it will seem to many simpler to accept the hypothesis that these iron and manganese oxyds in the porphyries and conglomerate beds, instead of having come from the replacement either of feldspar and quartz or of carbonate of lime, may have been deposited as we now see them.

Besides these ores associated with the Eozoic rocks, Dr. Schmidt describes several other classes of iron-ore deposits, one of the most interesting of which occurs in the sandstones immediately above the 3d Magnesian limestone above named, and often fills small basins or excavations in this sandstone, nearly vertical walls of which are seen to limit the ore-deposit. The ore in these is stratified, and is often both overlaid and underlaid by beds of clay, flint and broken sandstone, and, it is suggested, may have been deposited in cavities produced by a subsidence of the strata into caverns in the limestone beneath. The ore is sometimes specular red hematite, and at other times limonite, occasionally also magnetite, and sometimes includes rounded masses of ferruginous limestone with crystals of iron-carbonate. This association leads Dr. Schmidt to suggest as an alternative hypothesis, that these deposits may have been formed by the transmutation of limestone deposits previously occupying these basins. To this class belong the ores of the Merramec district.

In the Carboniferous series again, deposits of red hematite ore occur in sandstone, forming nodular or concretionary masses or regular beds. In one locality also, we have here described a large cavern or sink in the Receptaculite limestone at the summit of the Trenton, in which occur stratified layers of hematite and limonite,

with more or less heavy spar, the whole capped by a bed of crystalline heavy spar, including galena. The 3d Magnesian limestone is also metalliferous, and holds in drusy cavities crystals of pyrite and chalcopyrite. It sometimes contains more than the proportion of magnesian carbonate required to form dolomite, a not very common circumstance.

The coal measures of the state, belonging chiefly to the great western coal-field, and occupying an area of nearly 23,000 square miles, are described by Mr. Brodhead with much detail. The coal seams are generally thin, though some in the lower measures occasionally attain four feet. Their local value is very great from the scarcity of wood, and we are told in one place of a seam of from ten to fourteen inches which is wrought, the coal being sold at the mine for twenty cents a bushel. In regions where the product commands so high a price even small seams are precious. The coal deposits of Lincoln county in the eastern part of the state, belong, unlike those just referred to, to the central or Illinois field, and present the unusual character of detached basins of coal, sometimes twenty-five feet in thickness, with little or none of the usually accompanying strata, occupying depressions or previously excavated basins in the Lower Carboniferous limestone. These basins are very limited in extent, and have but a local importance.

The discussions of the various points with regard to the economic geology of the state, the chemical investigation of its iron ores, and the valuable appendix or investigations on the strength of building materials, all of which show good and thorough work alike for science and for the material advancement of the state, would occupy too much of our space. Since the regretted resignation of Prof. Pumpelly, on account of ill health, the direction of the survey has been confided to Mr. Brodhead, whose report for 1873, we have just received and shall soon notice. The beautiful atlas of maps which accompanies the report of 1872 should not pass unnoticed. These maps are from the establishment of Mr. Julius Bien of New York, who, by the admirable style of his work, has put all students of geology and geography under obligations to him. — T. S. H.

Relation of British Wild Flowers to Insects.[1] — The author prefaces his little work with the information that his observations

[1] On British Wild Flowers considered in Relation to Insects. By Sir John Lubbock. Nature Series. With numerous illustrations. London, Macmillan & Co. 12mo. pp. 179. 1875. Price $1.50.